

Cool waters and new bathymetry: a 2017 oceanographic survey in NW Greenland

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Trip Summary

From August 22 - September 3, 2017, we conducted an oceanographic survey of West and Northwest Greenland from Aasiaat (68.75°N 52.77°W) to Melville Bay (75.88°N 59.19°W). The main goals of this survey were to

- 1) Complete a multi-beam echo sounding (MBES) survey along key glacier fronts and fill in gaps left during the 2015 campaign conducted on MV Cape Race
- 2) Collect conductivity-temperature-depth (CTD) measurements along locations sampled in 2015 and in key, sparsely sampled areas
- 3) Deploy 2 ALAMO MRV probes - one in Upernavik fjord and one in Ummannaq fjord

The total distance traveled was over 1000 nautical miles (1850 km). Emily Kane and Mike Wood joined the S/Y Ividia in Aasiaat along with Nolvann Chauché de Gesnais (skipper), Paulie Chauché de Gesnais, and James Killingbeck. This crew transported the vessel to Upernavik where Eric Rignot joined. The MBES survey began throughout the fjords north of this region on August 25. Eric was dropped back in Upernavik on August 31, and the remaining crew transited with the vessel back south to Aasiaat.

The fjords of 10 glaciers – Kakvfaat Sermia, Qeqertarsuup Sermiat, Hayes Gletscher “NN”, Hayes Gletscher North, Kjer Gletscher, Kjer Gletscher N, Nansen Gletscher S, Nansen Gletscher, Nordenskiöld Gletscher, and Nordenskiöld Gletscher N (from south to north) – were surveyed during this time. Along the way, 10 CTDs were taken at key locations within the fjords and/or near the glacier termini. Additionally, two ALAMO MRV probes were deployed in Upernavik fjord and Ummannaq fjord.

Our bathymetric survey provided approximately XX km² of new MBES-derived bathymetry and supplements the previous campaign in several key area [details when I received the rest of the bathymetry from Eric]. The CTDs taken during this campaign reveal a freshening and cooling of waters below 200m as compared to the CTDs taken during 2015. The salinity differences from 2015 range from -0.12 kg/m^3 to -0.37 kg/m^3 while the potential temperature differences range from -0.18°C to -0.65°C .

1 Transit to Upernavik

At 9:30am, we departed Aasiaat harbor for Upernavik – a transit of nearly 500 km. The first 48 hours were characterized by strong southerly winds with gusts up to 40 kts and moderate swell conditions. There were several periods of light-to-medium rain and being at a relatively southerly latitude, the nighttime duration was 5-6 hours.

We arrived near Upernavik around 6:00am on August 24 to mostly clear skies and a calm sea state. Eric was not set to arrive until 7:00pm so we anchored in a nearby cove and used the time to catch up on sleep and meals, activate the first ALAMO probe for deployment, and prepare the MBES for the survey. After a day of preparation, we picked up Eric in the Upernavik harbor at 8:00pm and set off northward toward Kakivfaat Sermia.

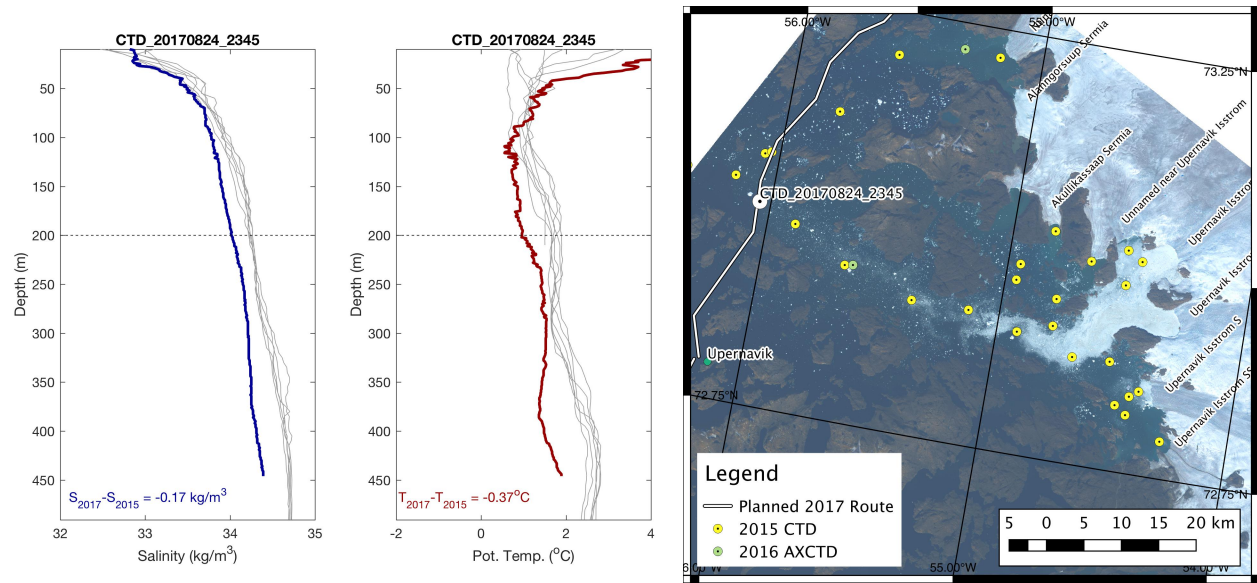


Figure 1: Salinity and Potential Temperature from CTD in Upernavik fjord. Grey lines indicate measurements from the 2015 campaign which are within 20km of our measurement, displayed in bolded color. Differences from 2015 are averages below dotted line.

2 Kakivfaat Fjord

CTD cast and ALAMO MRV deployment

As we crossed the main trunk of the Upernavik fjord system en route to Kakivfaat, we deployed ALAMO Probe #9146 at 72.993°N 56.045°W. The protective cardboard sheath was kept on the probe and when deployed, the probe remained buoyant on the surface for as long as we remained in the area. The weather was clear and sunny, the sea state was calm, and although there were plenty of large icebergs around, none were close (within 200m) of Ivalia.

In the same location, we took a CTD (CTD_20170824_2345) cast to 447m water depth. In the 2015 OMG survey, there were 7 CTD casts taken within 20km of this cast. Between 200m and

447m, the 2017 cast was 0.37°C cooler on average than the 2015 average and was taken 21 days later in the season (Julian Day 215 vs 236). The salinity was also 0.17 kg/m^3 fresher during this campaign as compared to 2015. See Figure 1 for details on this comparison.

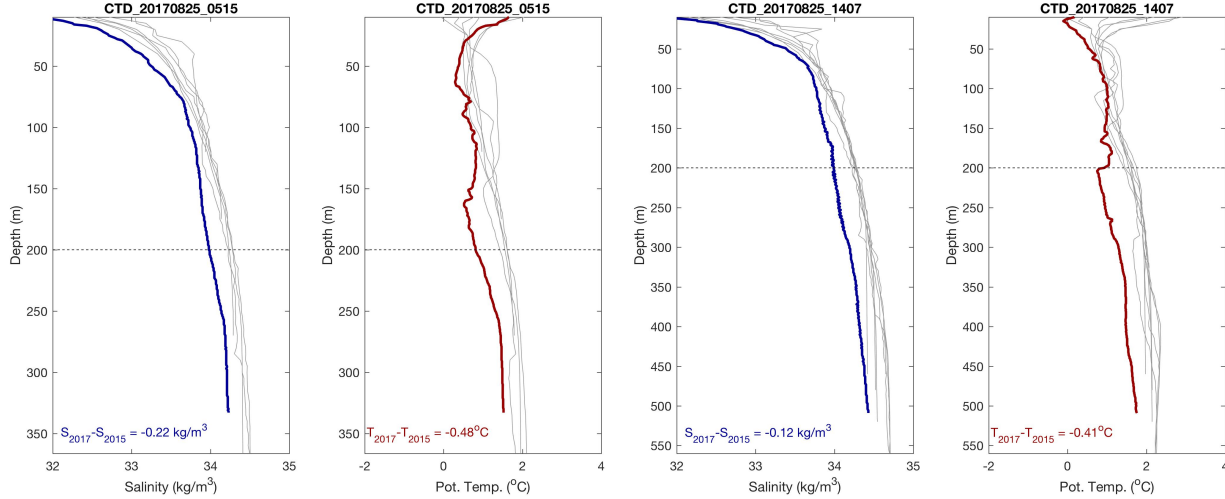


Figure 2: Salinity and Potential Temperature from CTDs near Kakivfaat Gletscher and Qeqertarsuup Gletscher, respectively. Grey lines indicate measurements from the 2015 campaign which are within 20km of our measurement, displayed in bolded color. Differences from 2015 are averages below dotted line.

Connection to Kakivfaat fjord

[We were in Kakivfaat Fjord for nearly 20 hours – survey details to follow when I received the bathymetry XYZ from Eric. CTDs are displayed in Figure 2 for reference].

Transit and CTD

Upon completion of this portion of the survey, we departed Kakivfaat fjord for the town of Kullorsuaq (Greenlandic: “Big Thumb”) approximately 150km to the north. The weather was clear moving into the night for the transit but there were moderate winds and a moderately bumpy sea state in advance of an impending storm. There were 1000’s of small (1-2m wide) icebergs especially on the shelf region outside the fjords of Illullip Sermia and Alison Gletscher (74.1°N to 74.5°N), requiring a watchful eye and attentive navigation.

Along the way, we took another CTD (CTD_20170825_2141) in the main trough which connects the fjords of Cornell Gletscher and Ussing Bræer to the continental shelf, reaching a depth of 458m. As for the previous measurements, this CTD also indicated cooler waters by 0.65°C in comparison to the more than 10 CTDs taken during 2015 in this area. The 2015 measurements were taken between Julian Days 217 and 250 in comparison to Julian Day 237 on which the 2017 measurement was taken (indicating that the cooling is an inter-annual difference rather than a seasonal signal). This was the largest difference in temperature measured during the entire survey. See Figure 3 for details.

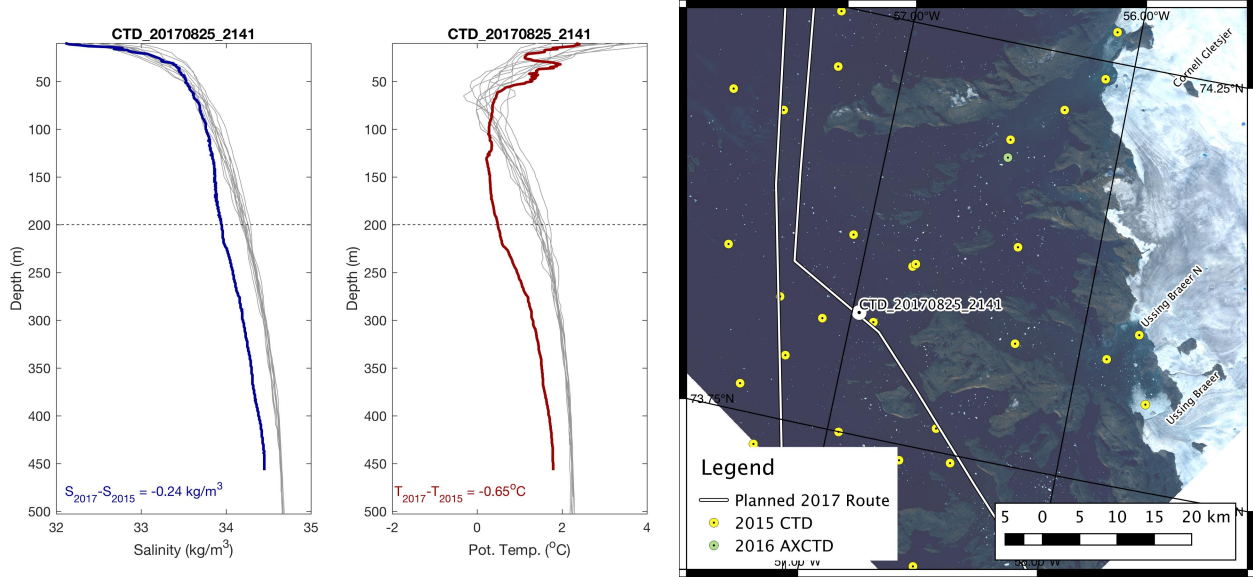


Figure 3: Salinity and Potential Temperature from CTD on shelf region outside Cornell Gletscher and Ussing Bræer. Grey lines indicate measurements from the 2015 campaign which are within 20km of our measurement, displayed in bolded color. Differences from 2015 are averages below dotted line.

3 Hayes and Kjer

We arrived at Kullorsuaq on the morning of August 26 around 7:00am. We attempted to purchase more diesel from the harbor but the hose was not long enough to reach Ivalia. As our fuel supplies were still sufficient for the next part of the survey, we abandoned the idea and continued our move north.

Hayes NN

The next glacier we attempted to survey was a branch of Hayes (branch “NN”, pending a more suitable name). The ice conditions were very dense within this fjord system, and characterized by a range of shapes and sizes from pancakes and bergy bits to large tabular icebergs. Still, we were able to fill in some gaps left in the 2015 campaign, and uncovered a shoaling bed near the front of Hayes NN. We were only able to reach within 4.5km of the ice face, leaving work still to be done in this fjord.

In the deep ($\approx 800\text{m}$) water of the main fjord, we took a CTD (CTD_20170826_1235) to 462m. The temperature difference between this cast and the 2015 casts was not as large as the previous CTDs, but there was still a difference of about 0.33°C . See Figure 4 for details.

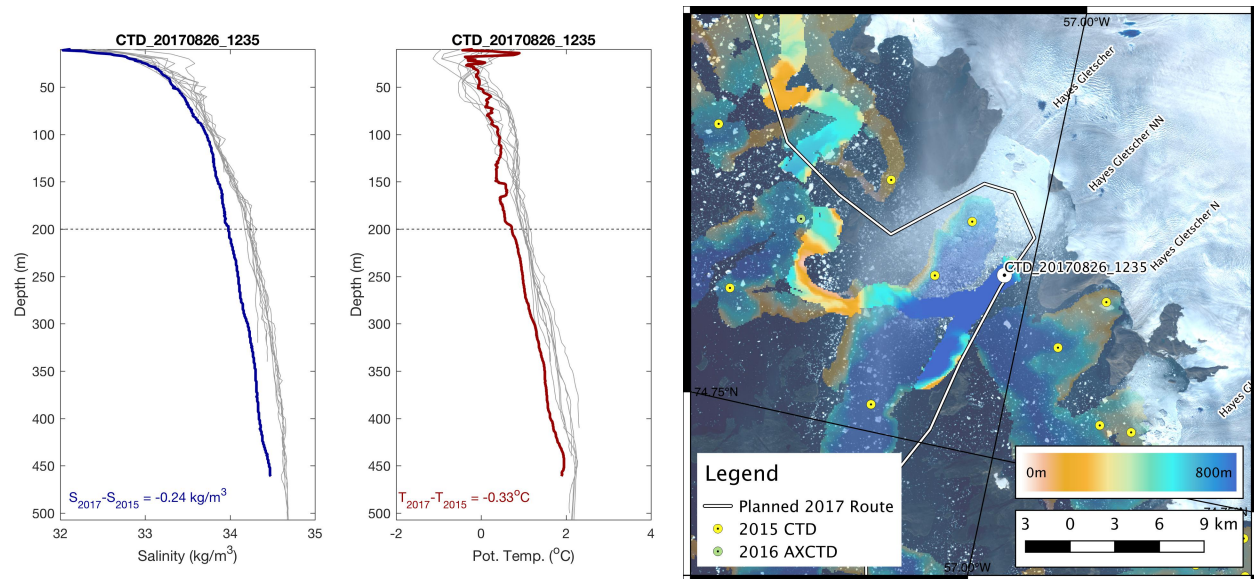


Figure 4: Salinity and Potential Temperature from CTD near Hayes Gletscher NN. Grey lines indicate measurements from the 2015 campaign which are within 20km of our measurement, displayed in bolded color. Differences from 2015 are averages below dotted line. Bright and transparent bathymetry in map indicates 2017 and 2015 surveys, respectively.

Hayes North and Kjer

After navigating out of the main Hayes fjord system, we headed north again to survey the expansive Hayes North Gletscher and adjoining Kjer glacier. Ice conditions were mostly clear in this area, allowing an unimpeded passage along the glacier termini which was not completed in 2015. On the approach toward Hayes North, we took a CTD (CTD_20170826_2038) to a depth of 218m. Even in this relatively shallow cast, the difference from the 2015 casts still shows cooler waters at depth. See Figure 5 for details.

Continuing north, more than 20km of survey was completed less than 1km from the glacier fronts. In 2015, there was no coverage of Kjer Gletscher's terminus, and this section of bathymetry may be one of the biggest gains of this year's survey. The bathymetry was very shallow in front of Hayes North (100m) but deepened by another 100m toward Kjer. After continuing as far as possible, we turned to head north and took a CTD (CTD_20170827_0040) in the deeper waters out toward the shelf, just after midnight. This cast showed a temperature difference of 0.64°C as compared with the 2015 data (Figure 6).

Next, we continued around an island in an attempt to survey the northern branch of Kjer Gletscher (which completely disintegrated this year and joined the rest of Kjer). Ice conditions were thick in this region so we were not capable of penetrating very far toward the glacier, but we took a shallow CTD (CTD_20170827_0443) cast to a depth of 193m. As averaged below 150m, even this shallow cast showed cooling of 0.5°C (Figure 6).

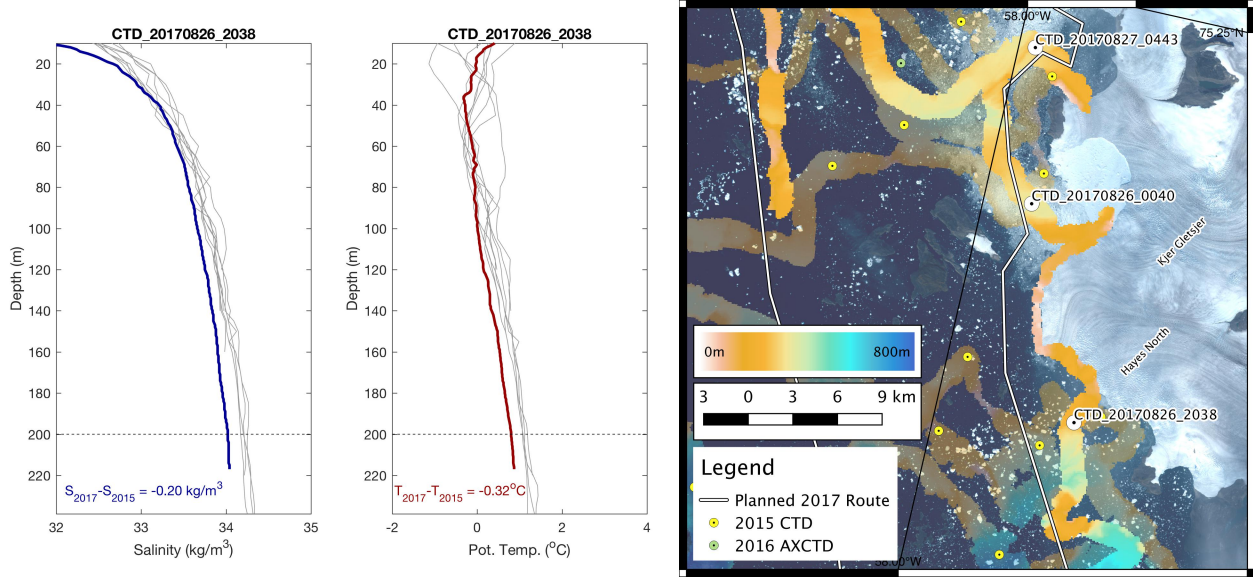


Figure 5: Salinity and Potential Temperature from CTD near Hayes Gletscher North. Grey lines indicate measurements from the 2015 campaign which are within 20km of our measurement, displayed in bolded color. Differences from 2015 are averages below dotted line. Bright and transparent bathymetry in map indicates 2017 and 2015 surveys, respectively.

Sheltered Anchorage

As we moved into August 27, a storm promising strong winds and heavy rain was beginning to take shape. We kept the MBES collecting data as we moved on the shelf region past Steenstrup, Dietrichson, and Sverdrup Gletschers to find shelter. We anchored at 75.658°N 58.504°W by 10:00pm on August 27 where we remained until the morning of August 29 when the winds started to subside.

4 Nansen and Nordenskiöld

By 6:00am on August 29, we were back underway and headed north toward Nansen and Nordenskiöld, just around a headland from our anchorage. The weather was still cloudy and raining with winds gusting up to 20kts but the area was largely protected so we carried on with our survey.

Nansen

The main branch of Nansen Gletscher splits into a smaller branch on its southern flank which offered relatively ice-free water. We were able to survey the entirety of this southern branch which had been left during the 2015 survey. As we continued north, we widened the swath in front of Nansen's main branch and took a CTD (CTD_20170829_1111) to 256m directly in front of the terminus. Again, the deeper waters were cooler than 2015, with a difference of 0.40°C.

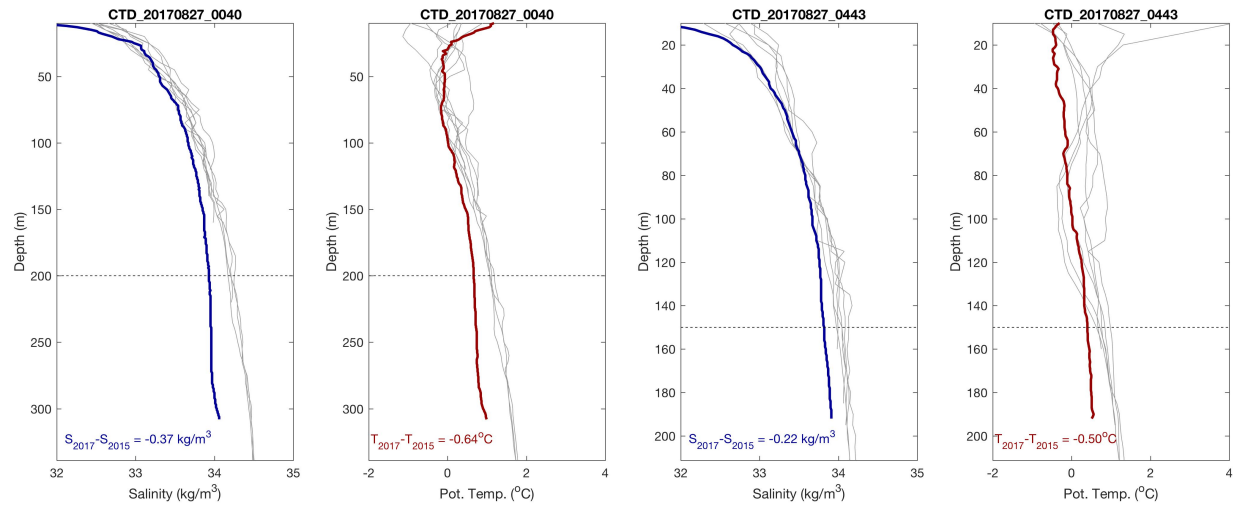


Figure 6: Salinity and Potential Temperature from CTDs near Kjer Gletscher. Grey lines indicate measurements from the 2015 campaign which are within 20km of our measurement, displayed in bolded color. Differences from 2015 are averages below dotted line.

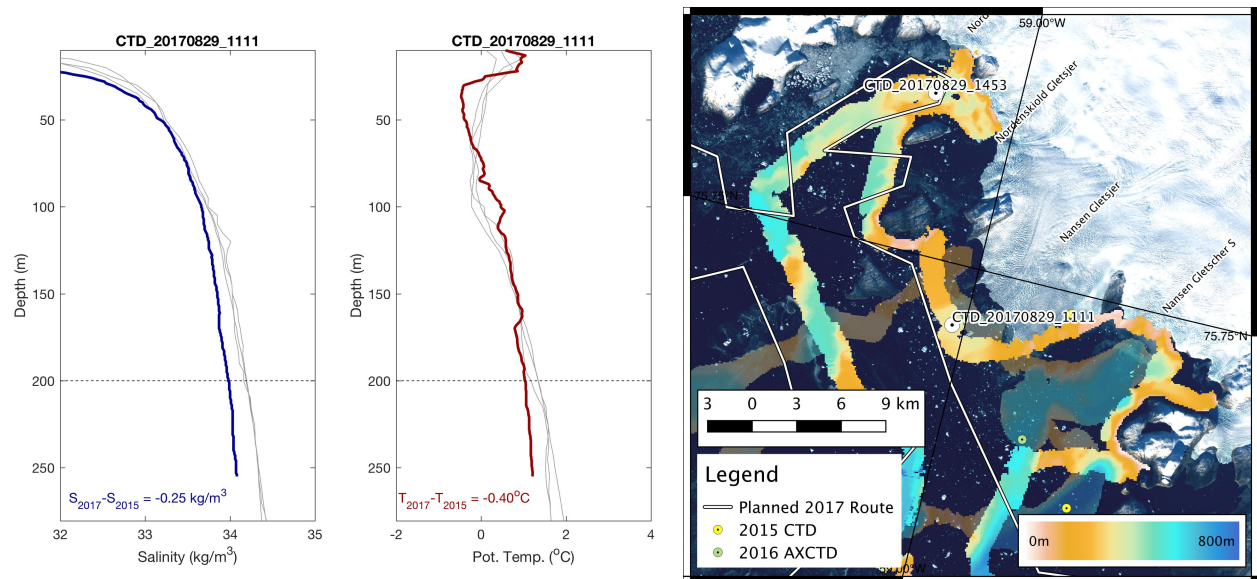


Figure 7: Salinity and Potential Temperature from CTD near Nansen Gletscher. Grey lines indicate measurements from the 2015 campaign which are within 20km of our measurement, displayed in bolded color. Differences from 2015 are averages below dotted line. Bright and transparent bathymetry in map indicates 2017 and 2015 surveys, respectively.

Nordenskiöld

From Nansen, we followed the coastline north, around toward Nordenskiöld under cloudy/foggy skies, and scattered showers. We uncovered shoaling bathymetry in the direction of Nordenskiöld's front but could not penetrate the thick ice conditions that were a combination of brash, pancakes, and very large icebergs. Around another tall, rocky island, we were able to re-join with Nordenskiöld's terminus, mapping more than 5km of additional coverage. The bathymetry revealed a shallow moraine 6-7km from the current front position where the glacier was likely grounded within the previous century. Facing time constraints and uncertain weather, we took a final CTD (CTD_20170829_1453) to 309m and departed the area. There were not any CTDs or AXCTDs taken in this area in the last 2 years of the OMG campaign, but one nearly 17km away on the opposite side of Nansen suggests a cooling at depth in this region as well (see Figure 8).

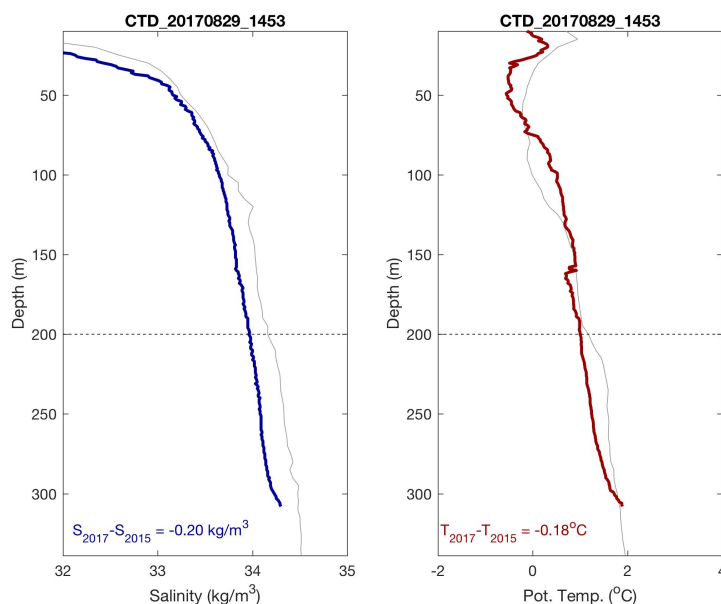


Figure 8: Salinity and Potential Temperature from CTD near Nordenskiöld Gletscher. Grey lines indicate measurements from the 2015 campaign which are within 20km of our measurement, displayed in bolded color. Differences from 2015 are averages below dotted line.

5 Transit to Aasiaat

After completing our survey in Nordenskiöld, we began our transit south toward Upernavik. The MBES was in operation for more than 100km of this journey, to the region around Kjer Gletscher. At this point, the MBES was removed because the vessel speed is significantly slower when it is in operation, and we were facing time constraints to get Eric back to Upernavik before his flight departed. The transit was again characterized by armadas of small (1-2m) icebergs which had to be carefully navigated. Additionally, there was a dense fog that limited visibility to only a few hundred meters. The most challenging navigation was in the fjords just north of Upernavik which we transversed slowly in the dark, keeping a sharp eye on the immediate horizon with the spotlight

as well as the radar. We reached the Upernavik harbor around 10:30 am on August 31 under cloudy skies where we began to disassemble the MBES rig and prepare the next ALAMO probe. We also successfully obtained the fuel which we missed out on in Kullorsuaq.

Another Anchorage

The weather report we received in Upernavik suggested strong southerly winds over the night from August 31 to September 1 – not optimal for an efficient transit. For safety, we again anchored for shelter in a protected region near the town of Upernavik. As the winds began to pick up, we exchanged short night shifts to watch the anchor and ensure we did not dangerously drift into nearby rocks overnight.

Final Transit to Aasiaat

On September 1, the weather was sunny and the winds began to calm – a perfect start to the 500 km transit back to Aasiaat. We departed around 11:00am through an inner fjord passage. By the morning of September 2, the winds turned northerly and the sun was shining – prime conditions for our southerly transit. We arrived at the mouth of Ummannaq fjord and by midday (12:56pm) where we deployed the second ALAMO Probe (#9146) at 70.827°N 55.437°W. As night neared, the clouds began to fill in, and we finished the transit to Aasiaat under cloudy skies, arriving at the harbor around 3:00pm.